METHOD AND APPARATUS FOR MODIFICATION OF BASIC GOOD FORECASTS

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BACKGROUND OF THE INVENTION

Reorderable goods for resale are sometimes called basic goods. The ordering, post allocation and distribution of basic goods involves significant stakes for operators. Many forecasting methods have been developed to help operators estimate the quantity of basic goods which will be sold and the supporting stocking levels which are needed. Mere forecasting does not address certain real world considerations; in many ways, projected demand requirements are just a starting point for processes of ordering, post allocation and distribution of goods. Useful methods should modify projected demand requirements to reflect real world considerations, before decisions are made to order, post allocate or distribute goods.

At the beginning of a product lifecycle, it is useful to bring goods into stocking and selling locations in a sensible fashion. In a multi-layer or complex distribution network, such as one involving national and regional stocking locations, there can be substantial complexity in ordering, post allocation and distribution of goods.

During a product lifecycle, projected demand requirements for selling locations may be refined to meet the real world considerations of presentation quantities and stockouts at selling locations. One approach that selling locations may use is to display goods in special shelves, racks or other presentation fixtures in order to make an attractive presentation which enhances sales. This approach creates a need for presentation quantities of goods at selling locations which can be distinct from and larger than projected demand requirements. It is useful to modify projected demand requirements to reflect presentation quantities.

At selling locations, stockouts sometimes prevent the selling locations from fulfilling the projected demand requirements. In some instances, stockouts become inevitable and foreseeable weeks or months in advance, due to the length of the cycle in which orders to suppliers lead to shipment of goods through stocking locations to selling locations. It is useful for a system to compare projected on hand inventory

with projected demand requirements and reduce the projected demand requirements when stockouts at selling locations will prevent fulfillment of the projected demand.

At the end of a product lifecycle, it is useful to deplete inventory in stocking and selling locations in a sensible fashion. Again, in a multi-layer or complex distribution network, there can be substantial complexity in ordering, post allocation and distribution decisions which resulted in orderly depletion of goods.

It is therefore desirable to have a method and system which modify projected demand requirements, however forecast, to reflect certain real world considerations related to ordering, post allocation and distribution of goods.

SUMMARY OF THE INVENTION

An aspect of the present invention includes a computer implemented method of rolling up projected demand requirements for a plurality of selling locations. This includes, associating respective selling in-dates with a good at a plurality of selling locations; associating respective time elements, corresponding to times for an action to lead to availability of the good at the respective selling locations, with the good at the selling locations; and looking forward from a date related to the action and rolling up projected demand requirements for one or more predetermined selling periods, which commence at one or more dates related to the respective time elements, for the good at the selling locations. Other aspects of the present invention are described in the claims, specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts a stocking to selling location distribution coverage cycle.

Figure 2 depicts a total coverage cycle.

Figures 3-4 depict a multi-layer or complex distribution network and a total coverage cycle for multiple locations.

Figure 5 illustrates handling of selling in-dates at particular selling locations.

Figures 6-7 illustrate user interfaces for in dates, out dates and time elements of a coverage cycle.

Figures 8-10 illustrate forecast correction in the case of stockout for a single location, with and without backorder correction, and for two locations.

Figure 11 illustrates handling of selling out-dates at particular selling locations.

DETAILED DESCRIPTION

The following detailed description is made with reference to the figures. Preferred embodiments are described to illustrate the present invention, not to limit its scope, which is defined by the claims. Those of ordinary skill in the art will recognize a variety of equivalent variations on the description that follows.

Goods may be distributed to selling locations from suppliers and stocking locations in a variety of patterns. Selling locations may be retail stores operated by a retail chain or its franchisees. Selling locations for catalog or online retailers may be distribution centers. For distributors, selling locations may be distribution centers. Suppliers may operate distribution centers or plant warehouses as selling locations. Selling locations, as used herein, refers broadly to locations from which an operator draws the inventory which it sells to others. Both selling and stocking locations have on hand inventory of goods. The stocking locations, as used herein, refers to inventory locations which distribute goods to selling locations. In a simple distribution network, a group of selling locations may be supplied with goods from a single national distribution center which acts as a stocking location. In a multi-layer distribution network, one or more national distribution centers may distribute goods received from suppliers to regional distribution centers, which, in turn, distribute goods to selling locations. In this case, both the national and regional distribution centers are stocking locations. In a complex distribution network, goods may flow from suppliers to both stocking and selling locations; goods may be distributed from one level of stocking location alternatively to either another level of stocking location or directly to selling locations. Most generally, stocking and selling locations can be considered as a network, rather than a hierarchy of distribution channels.

Projected demand requirements are typically forecast. The methods and devices of the present invention can apply real world considerations to projected demand requirements regardless of the manner in which the forecast is made. Finely granular forecasts, preferably using day by day or more frequent time intervals, are preferred, but not absolutely necessary to the present invention. The focus of forecasting is to project demand requirements at the selling level. Inventory at stocking locations is arranged to support sales from selling locations, not for its own sake. Projected demand requirements reflect demand for goods to be sold. In some instances, projected demand requirements may be stated as desired stocking levels at

the selling locations. Desired stocking levels may reflect addition of so called safety stock to demand for goods to be sold. The safety stock is one way of protecting against variations of actual sales from projected demand for goods to be sold. However projected demand requirements are determined, it is useful to adjust projected requirements to take into account real world considerations.

Decisions which impact the availability of goods at selling locations lead to ordering, post allocation and distribution actions. Ordering may include placing purchase orders on a company wide, stocking location or selling location basis. Between the time that orders placed with a supplier and goods are ready to ship from the supplier, a post allocation action may direct the supplier's goods to certain locations, either stocking or selling locations. Goods in stocking or selling locations may be distributed to other stocking or selling locations. An action directing distribution of goods determines the movement of goods among any combination of stocking and selling locations.

The time for an action announcing or implementing a decision to lead to availability of goods at a selling location can generally be referred to as cycle. A plurality of time elements are combined in a cycle, such as a cycle which begins with the assembly of on hand inventory data at stocking and selling locations and extends until a second delivery becomes available at the selling location. A simple distribution cycle can be illustrated with one stocking location and one selling location.

Figure 1 illustrates a simple distribution network, having one stocking and one selling location. The coverage cycle 130 in this figure includes time from when on hand data is obtained (potentially with some lag time before processing or review begins) 133, until a next delivery (after the current delivery being planned for) has arrived at a selling location and is available 132. This coverage period may be referred to as a predetermined selling period, for some purposes. There is only one level in this example of a distribution network. Indicated as by the dotted line 131, this delivery, being planned for, becomes available at the selling location during the coverage cycle. A distribution review cycle 133 is a time in which begins with the availability of data. It corresponds to the time between this and the next shipment, and allows inventory personal (if human intervention capability is desired) to consider data and system generated recommendations, potentially including recommendations

for ordering, post allocation and distribution. With or without intervention of inventory personnel, time is allowed for data processing 135, which may include generation of directions or pull orders to stocking locations. At a stocking location, time is allowed for picking goods 137 and readying them for shipment to selling locations. A time element is then included for for shipment of goods to selling locations 139. Optionally, a time element can be provided (not in figure 1) for unpacking and displaying goods at the selling location. In figure 1, time elements 134, 135, 137, and 139 combine into a coverage cycle 130. An action directing distribution of goods sometime during the distribution review cycle 134 results in availability of goods at the selling location 132 after several time elements have passed. The goods that become available at the selling location from this delivery 131 may be used by the selling location to fulfill projected demand requirements for an interval of a predetermined time selling period, such as the time from this to the next delivery of goods. Alternatively, they may satisfy presentation requirements during the interval. If too few goods are available at the selling location from delivery 139 through the subsequent delivery, either presentations may suffer or projected demand requirements may go unfulfilled.

Variability in the time for an action to lead to availability of the good at respective selling locations is illustrated in figure 2. This figure illustrates a distribution network having one supplier, one stocking location and a plurality of selling locations. On hand inventory data is available at the beginning 221 of the overall coverage cycle 250. An order review cycle 224 corresponds to the time between this and the next order, and permits inventory personal or the system to place an order with a supplier. The selected point in time corresponding to the next shipment typically is when another an order will be placed, leading to availability of the good at the selling location. In cases where orders are placed as soon as there is some need or some minimum need for the good, this time period could be very short. Supplier lead time 225 reflects the time for the supplier to respond to the order and for goods to become available at the stocking location. The so-called pipeline includes time for placing orders with a supplier and having goods available at the stocking location for distribution to selling locations. A plurality of time elements combined into a pipeline coverage cycle 240. Various periods of coverage cycles 130A-C create

variability in the total coverage cycle 250. Due to this variability, various start and stop dates apply to one or more predetermined selling periods for the selling locations.

Single and variable coverage cycles for a multi-layer distribution network are illustrated in figures 3 and 4. Figure 3 illustrates a single overall coverage cycle involving a supplier, a national stocking location DC B, a regional stocking location DC 4 and selling location store 2655. The overall coverage cycle includes a pipeline coverage cycle 340, post allocation coverage cycles 360, national to regional stocking location coverage cycles 350, and stocking to selling location coverage cycles 130. On hand data is obtained (potentially including lag time for processing or review) 301. A single order of goods is placed with a supplier. After time 302, the system processes data for post allocation 303 and a post allocation review time corresponding to time between this and the next post allocation decision or action 304. In this example, at least part of the order for the good is shipped from the supplier to the stocking location national DC B in time 305. Data processing and review of recommendations time 306, 307 allows decision-making and directions to ship the good from one level of stocking location to another. In this example, the good is shipped from national DC B to regional DC 4 in time 308. The cycle for distribution of the good to the selling location (from regional DC 4 to store 2,655) is time 130. Only one post allocation coverage cycle 360 and one coverage cycle 350 appears in the figure, because only one distribution path is illustrated.

Figure 4 builds on figure 3, adding the complexity of multiple distribution paths. Differentiation of distribution paths first appears at 305A-B, as different time is required for shipment from the supplier to stocking locations national DC A and B. Time elements from an action to availability of the good at respective selling locations are further differentiated at 308 A1-2 and 308 B1-2, due to varying shipment time from a first level of stocking location (national DCs) to another (regional DCs.) Still further differentiation appears in stocking to selling location distribution, 130A-B. From these diagrams, the impact of assigning one or more selling in dates can be illustrated.

Figure 5 builds on figure 4, adding selling in dates 570A-D for stores 1, 800, 801 and 1400. In this figure, stores 1402, 2,238, 2,242 and 2,655 have coverage cycles that do not approach the selling in date 570. Although the same selling in date is illustrated in this figure for all selling locations, a respective selling in dates for the

selling locations can alternatively be regionally or logically grouped or even different for each selling location.

A method applying the present invention uses in dates to modify projected demand requirements. On a computer system having memory for programs and memory for data, a program is used associate respective selling in dates with a good at a plurality of selling locations 570A-D. The selling in date may be a date on which selling of the good is scheduled to begin at a particular location. Respective selling dates may be assigned to a plurality of locations. A selling in date for the good may be assigned to all or substantially all selling locations, by one or more user actions, to predetermined groups of selling locations or to a single selling locations. A user interface may allow the user to select selling locations from a list using a standard protocol from a Windows environment. For instance, a block of selling locations may be selected using a hold and drag command, including pointing a mouse cursor at a first selling location on a list, depressing a mouse button and dragging the mouse cursor to another selling location, leading contiguous block of selling locations highlighted. The same effect may be accomplished with the wheel mouse by rotating the wheel to drag the mouse cursor to the other selling location. Another way of selecting contiguous selling locations may be to click on a first selling location, move the cursor to another selling location, depress the shift key and click on the other selling location. Noncontiguous selling locations may be selected from a list by depressing the Ctrl key and issuing mouse click commands or the mouse first or his point and various selling locations. A user interface may allow a selling in date to be assigned to all selling locations and then modified for selling locations or groups of selling locations which are different from the first assigned in date. A checkbox interface for assigning either selling in dates or selling out dates, or both his illustrated in figure 6. One or more goods can be selected from the left-hand list. One or more locations can be selected from the right hand list. In dates and out dates can be specified. Values can be added, change, deleted or listed using this user interface.

Respective time elements, corresponding to times for an action to lead to availability of the good at the respective selling locations, are associated with the good at the selling locations. Availability may include delivery of the good at a selling location from a distribution center. It may further include preparing the delivered goods for sale at the selling location. The time elements may include any or

all of the time elements illustrated in the previous figures, including include time required to collect data, review action recommendations, process data, pick goods at a stocking location, and ship the goods to a selling location. The time elements may further include periodic dates for actions necessary may be good available at the plurality of selling locations. For instance, shipments from a particular stocking location to a particular selling location may only take place on Wednesdays. Thus, the cycle time from issuing distribution orders to stocking location availability of goods at particular selling locations may vary, depending on the day of the week when the distribution order is issued, and may be accommodated by the system. In other cases the shipments may occur on an as needed basis. The respective time elements may include time for distributing the good from one or more first level stocking locations to a plurality of second level stocking locations, as in a multi-layer distribution network. Periodic dates for actions may be combined with time elements for a multi-layer distribution network. The respective time elements may include time for distributing the good from the supplier through one or more stocking locations to a plurality of selling locations. Periodic dates for actions may be combined with time elements for distributing the good from supplier through stocking locations to selling locations. The action which results in availability may be distributing the good from one or more stocking locations to a plurality of selling locations or it may be issuance of an order directing distribution of the good. Alternatively, the action may include ordering the good from a supplier or post allocation (allocating) delivery of the good to stocking or selling locations sometime after ordering the good from supplier.

An interface for associating certain time elements with one or more goods at one or more selling locations is illustrated in figure 7. This interface may use any of the conventions described above or any equivalent conventions for associating good-location pairs with time elements. In this illustration, the time elements include lead time, review cycle and data lag in the distribution of goods from a stocking location to a selling location. The same interface can be applied at the level of distributing goods from a first level (e.g., national) stocking location to a second level (e.g., regional) stocking location. One could easily associate other time element components with good-location pairs, such as order assembly lead time, handling and processing time, or shipping and delivery time.

Associating respective selling in-dates and time elements with the good at the selling locations is usefully combined with looking forward and rolling up projected demand requirements, taking into account the selling in-dates. Looking forward means looking forward into the future from a particular date. The date may be the date of the on hand inventory data (133, 201, 301), the date on which analysis is performed, a proposed date for a decision or action, or any other date related to the decision or action. The decision or action may involve ordering the good from a supplier, post allocating the supplier's delivery of the good or distributing the good among stocking and selling locations. The look ahead extends to one or more time periods following the impact of the decision or action on availability of the goods at the selling location 131, to determine how the decision or action can help fulfill the projected demand during one or more predetermined selling periods. One useful predetermined selling period includes the look forward date through the date when the next delivery of the goods is available at the selling location 132. Then, the impact of the decision or action being taken is taken into account. A useful interval of the predetermined selling period to focus on, for instance for analysis of presentation quantities, is from the date when this delivery of goods becomes available at the selling location 131 through the date when the next delivery of goods is available at the selling location 132. For instance, if intermediate totals from prior runs have been kept, it may be possible to focus on just the selling period most directly impacted by the decision or action under consideration. When the projected demand requirements are rolled up, there are alternative ways of taking into account the respective in dates. Projected demand requirements, whatever they are, can be zeroed for all dates prior to the in date for the respective good-selling location pair. Alternatively, the system can test projected demand dates against the in date and ignore projections predating the in date. In some methods, the forecasting tool may have access to the associated in dates and time elements and may assign a zero demand requirement to dates preceding the in date, in which case, virtually any way of taking into account the respective in dates will work, because nothing in particular is necessary.

Another real world consideration is presentation quantities. Selling locations may choose to display goods in specials shelves, racks or other presentation factors in order make an attractive presentation which enhances sales. Fixtures used for presentation may include tables, rounders, four walls, wall shelving, promotion tables,

tills or display windows. Large square footage stores may have more presentation fixtures than small square footage locations. Presentation quantities also may very for reasons other than location physical characteristics, such as the sales level at the location.

It is useful to associate presentation quantities and presentation dates (e.g., start and end dates for the presentation) in advance of use in ordering, post allocation or distribution analysis. Presentation quantities can be tracked rigorously or on an exception basis. Rigorous tracking could include a buildup of presentation quantities for every good in every selling location. A user could assign each good to at least one fixture and assign dates that each fixture setup would be used on a particular fixture. Given reference information regarding which fixtures are associated with or in which selling locations, the system could assign presentation quantities by time and selling location. Alternatively, a user could set presentation quantities only for items prominently featured, which have presentation quantities that would significantly impact ordering, post allocation or distribution of goods.

One way of associating presentation quantities with a good at a selling location is to create a unique name for a particular fixture, promotional display point or other mode of presentation. A set of named fixtures are then associated with each selling location. When the layout of a selling location changes, different named fixture can be associated with the location. Fixture setups are associated with the fixtures for particular goods and periods of time. The named fixture setups can be assigned specific quantities (capacities) of goods per fixture setup or fixtures can be assigned different good quantities per fixture for different periods of time. The end result is that the system takes into account the capacities of named fixtures and the number of named fixtures at each selling location when it calculates presentation quantities. For good selling location pairs, one or more of the available setups at the selling location can be allocated to the good. In this approach, the system can calculate the presentation quantity from assignment of goods to particular setups in particular fixtures.

Alternatively, inventory personal could directly assign presentation quantities on a good location pair basis. An interface similar to those in figures 6 and 7 may be useful for associating presentation quantities and dates with the good at a plurality of

locations, regardless of whether fixtures and fixture setups are used as proxies for presentation quantities or presentation quantities and assign directly.

As a next method step, respective time elements, corresponding to times for an action to lead to availability of the good at the respective selling locations, are associated with the good at the selling locations, as described above in the context of selling in dates.

Associating respective presentation quantities, presentation dates and time elements with the good at the selling locations is usefully combined with looking forward and rolling up projected demand requirements, taking into account the presentation quantities and presentation dates. As explained above, looking forward means looking forward into the future from a particular look forward date. The date may be the date of the on hand inventory data (133, 201, 301), the date on which analysis is performed, a proposed date for a decision or action, or any other date related to the decision or action. The decision or action may involve ordering the good from a supplier, post allocating the supplier's delivery of the good or distributing the good among stocking and selling locations. The interval during which the presentation quantity affects the analysis is the time between when this delivery 131 and the next delivery 132 will be available at the selling location. This interval is analyzed because it is when this action will lead to this delivery and will impact the inventory level at the selling location.

When the projected demand requirements are rolled up, there are alternative ways of taking into account presentation quantities, which depend to an extent on the decision or action being taken. One manner of taking into account presentation quantities is tracking their impact on a so-called model stock for a selling location. A model stock can be calculated, taking into account presentation quantities, using either of the following equations:

ModelStock(selling location, good) = Maximum of ((PresentationQuantity(selling location, good, time), DemandProxy(selling location, good)) + SDM(selling location, good, time)

or,

ModelStock(selling location, good) = DemandProxy(selling location, good) + PresentationQuantity(selling location, good, time) + SDM(selling location, good, time)

If the first equation is used, the quantity available in the stocking location will be allowed to fall below the presentation quantity between receipt of distributions. If the second equation is used, the presentation quantity will be protected; the quantity available in the location should not typically fall below the specified presentation quantity between receipt of distributions. Variables in these equations include:

PresentationQuantity(selling location, good, time) is determined using either of the approaches described below.

DemandProxy(selling location, good) may be a measure of projected demand requirement for the coverage cycle. It typically includes projected selling and safety stock forecasts. For the present invention, virtually any *DemandProxy* can be modified to reflect the real world consideration of presentation quantities; the manner in which the *DemandProxy* is calculated is not a part of the present invention.

SDM(selling location, good, time) is a shorthand for "special display minimum." It is a user specified value that can be directly assigned. For instance, a SDM may be useful when using the first equation above and desiring to protect a special display quantity from being sold during the coverage cycle (such as an item in a display window that you are not willing to sell during the display period). It can also be used as an additional safety factor to cushion model stocks against problems of poor data integrity.

When the decision or action of concern involves a distribution, the model stock equations can be extended to calculate distribution quantities. One equation for this calculation is:

DistributionQuantity = ModelStock(selling location, good) – Onhand(selling location, good) – Intransit(selling location, good)

Variables in the equation include:

ModelStock(selling location, good) from prior equation(s).

Onhand(selling location, good) is the quantity of the good at the selling location, based on the available information.

Intransit(selling location, good) is the quantity of the good in-transit to the selling location. This quantity would include quantities already allocated but not picked, as well as quantities picked but not shipped, and quantities physically in-transit to the selling location.

These distribution quantities may then get adjusted by further factors such as minimum distribution quantities, shipment increment quantities (e.g., that shipments are in multiples of 120 but not in between), case pack quantities (e.g., shipments are in multiples of the physical shipment case) and distribution center stock availability (in the event of the total shipment desired for an good being more than the DC has available some logic is applied to send out the quantity available in the manner that will best support it going to the stores most likely to need it first). Application of any one of these may be as simple as any positive distribution quantity below the minimum distribution quantity gets moved up to the minimum distribution quantity or there may be logic that says anything below x percent of the minimum distribution quantity is rounded down to 0 and the rest are rounded up.

When the decision or action involves ordering goods, an order quantity for can be determined as follows:

OrderQuantity = OrderPipelineModelStock + SumOfLowerModelStocks – LocationOnHand – LocationOnOrderInTransit – LowerOnHand- LowerOnOrderInTransit

The variables are:

PipelineModelStock is an economic stocking level calculated for the Pipeline coverage cycle currently being determined. The *OrderPipelineModelStock* is calculated for the Order Pipeline coverage cycle, for example shown in Figure 3-4, in a manner identical to the *ModelStock* described above in the distribution calculation, except that it is done for the Order Pipeline coverage cycle and using the time period *DemandProxies* supplied for the Order Pipeline coverage cycle for the specific time period being done and recognizing that frequently it is not done for an activity coverage cycle that includes presentation quantities and SDMs.

The *SumOfLowerModelStocks* is equal to the sum of the *ModelStocks* for all other cycles within the overall activity cycle. So in the case of figure 4 it would include the *ModelStocks* for all the post allocation cycles, all the national DC distribution coverage cycles and all the regional DC to selling location coverage

cycles. The *ModelStock* for each coverage cycle is calculated using one of the equations above recognizing the most non selling locations do not have any presentation quantities or *SDMs*.

LocationOnHand is the quantity on hand for the stocking location, if there is one in the coverage cycle currently being calculated. Note that if another coverage cycle within the overall coverage cycle being done has already included the inventory on hand, then it is not double counted. In the case of the order in Figure 4 there is no stocking location within the Order Pipeline coverage cycle so the OrderLocationOnHand will be zero. However, within the Post allocation cycle you have the inventory in the 2 National DCs, National DC A and National DC B which would be included. It should be considered that the quantity on hand may differ by activity because a distribution being done right now may not include inventory in rework that is not immediately available but when calculating the distribution quantity on hand for an order that will arrive well out into the future then that rework quantity will be counted as it will be available well before the next order is received.

LocationOnOrderInTransit is equal to the quantity that the stocking location or locations, has being delivered to it within the coverage cycle. It usually includes outstanding purchase orders and any intransit goods coming to the location and can include other forms of commitments that have been made. Like *LocationOnHand*, if a quantity has already been counted in the other cycles within the overall cover cycle, it is not double counted.

LowerOnHand is equal to the sum of the number of units on hand in all locations (at any level of the hierarchy) within the later coverage cycles that complete the overall coverage for this activity (avoiding double counting.)

LowerOnOrderInTransit is equal to the sum of the number of units credited as on order or in-transit (at any level of the hierarchy) to any location within the later coverage cycles that complete the overall coverage for this activity (avoiding double counting.)

These formulas may be useful in rolling up projected demand requirements and presentation quantities for the good at the selling location. For each of these formulas, a particular presentation quantity may need to be selected, when there are a variety of presentation quantities within the period of concern. In a coverage cycle, there may be multiple different PQs, for instance, when a presentational or

promotional event takes place in the middle of the cycle but not at either end. In the case of multiple different PQs, a number of approaches can be taken to selecting a PQ to use. One option is to use the PQ for the location on the last day of the coverage cycle. This will ensure that you end up with the desired PQ factored in on the last day. Another option which generally results in higher stocking levels is to use the maximum value during the cycle. This is useful for a presentational event which is shorter than a review cycles. It covers the peak PQ value for the activity. Another option is to use the maximum value of the PQ within the dates between distribution coverage cycle end date and an earlier date reflecting the length of the distribution review cycle. This option delivers the maximum PQ value between when the current shipment or distribution arrives and when the next shipment arrives. Another option is to use the value on the date that the desired activity goods are received at the location. This date, if not otherwise indicated in the system, can be determined by subtracting the length of the distribution review cycle from the distribution coverage cycle end date. Thus, a preferred PQ for a coverage cycle can be selected.

A third real world consideration is stockouts, which occur when on hand goods at a selling location are inadequate to meet a projected demand requirement, a desired presentation quantity, or both. According to this aspect of modifying a projected demand requirement, inadequate on hand inventory may result in unfulfilled demand at a selling location. To the extent that this demand results in buyers going elsewhere, it is never realized and the system reduces the total projected demand requirements over time to reflect the unfulfilled demand. To the extent that a portion of the demand is recaptured, by waiting lists, rain checks or the like, the total projected demand requirements over time are reduced to reflect the portion of the demand which is unfulfilled. Alternatively, the system can flag significant stockouts and seek intervention of inventory personnel.

Stockouts can be detected by comparing daily or more frequent projected demand requirements with daily or more frequent projected on hand stock for good at a plurality of selling locations. Then, projected demand requirements are reduced corresponding to unfulfilled demand for at least one of the selling locations or stockout has been detected. When the system looks forward and rolls up projected demand requirements, for one or more predetermined selling periods commencing at one or more dates corresponding to time this for an action to lead to availability of

good at the selling locations, the total projected demand is less than if it were not adjusted to reflect stockouts. The model stock formulas set forth above can be modified to reflect stockouts:

ModelStockStockoutCorrected(selling location, good) = Maximum of ((PresentationQuantity(selling location, good, time), StockoutCorrectedDemand Proxy(selling location, good, time)) + SDM(selling location, good, time)

or,

ModelStockStockoutCorrected(location, item) = StockoutCorrectedDemand Proxy(selling location, good, time) + PresentationQuantity(selling location, good, time) + SDM(selling location, good, time)

StockoutCorrectedDemandProxy starts with the daily (or shorter time period if that is what is used) average *DemandProxy* and its comparable daily average *ProjectedSales* and then looks at the on hand situation for the location in question to determine whether there is sufficient stock to support the selling. If there is sufficient stock, then it does not adjust the average *DemandProxy*. If there is insufficient stock to support the sales, then that day's *DemandProxy* is reduced to reflect the inventory shortfall. That reduction can be done a number of ways with one of the most prevalent being to simply zero any *DemandProxy* value greater than the remaining on hand inventory on the preceding day and to then zero the inventory on hand at the end of that day. These calculations continue day-by-day (or shorter time period if that is what is used) until the products from this activity show up at the location at which point there will be ample stock available unless the location sending the product has insufficient available product to meet the desired shipment. If a stock shortfall is then the case in the sending location then that shortfall is also factored in to the *DemandProxy* calculations from the arrival of the shipment until the end of the coverage cycle. The reduced shipments caused by the sending location shortage are then distributed to the various locations and then the above method used to determine whether a give location runs out of stock and therefore reduces the daily *DemandProxy* value. Once all those calculations are done then the *StockoutCorrectedDemandProxy* is the summation of all the daily *StockoutCorrectedDemandProxies* within the coverage cycle.

As discussed in the distribution example calculations above, with reference to orders and post allocations, the system also can correct forward forecasts, however made, to reflect the impact of stockouts. Suppose that a forecast is made of daily or more frequently stocking levels of all the stocking and selling locations into the future, and demand requirements are also projected. We then estimate based on the forecasted selling and the timing of shipments from suppliers and the flow of goods through the supply chain when a selling location is likely to be out of stock. On those stocked out days we identify the projected lost sales and then since those sales are not projected to take place we reduce the forecasted needs back through the supply chain. So in doing this we have not just made forecasts of what would happen but made those forecasts specific to the dates of shipments and the like which have been set in motion for this particular item at this particular moment. As you will see in our examples of this we have also not only done this for a single element activity but have done this for activities that span numerous stocking locations and supply chain considerations.

In our first example, see Figure 9, we lay out a situation where forecasting without working through the actual timings of what will occur would result in overstocking of the location by 9 units. A forecast that did not look forward and know that the location was going to stock out on day 5 and be out of stock until day 10 would predict needing 25 units over the coverage cycle while one taking into account the actual day by day selling and stocking would instead forecast a need of 16 units to support sales with of course and additional safety stock number, but the stockout determination would identify lost sales of 9 units that do not need to be sent to the location. You may also convert some of the stockout period potential sales to real sales by some mechanism like a back order. In that case you would not totally lose the sales during the stockout time period but as done in Figure 10 would convert some of them to later sales. The way the system does that is essentially accruing a fraction, in Figure 10 - 33 percent, of the otherwise lost sales and then taking them on the days that they would have been sold if stock was available or more correctly actually realizing those sales when the goods show up in the store as indicated in the final row of Figure 10 with the 6 unit sales on day 11 (3 above what you would have otherwise sold).

The single location distribution scenario is one of the simplest. When looking at ordering for a Distribution Center or a National Distribution Center we project out how all the selling locations serviced by those Distribution Centers will stay in stock. What occurs here is contingent upon the stocking rules at hand which can range from allowing cross transfers between locations and Distribution Centers and Distribution Center distributions to locations in another Distribution Center's region to allowing none of the above. In all of the cases our system will model what will happen as the days progress and the system attempts to keep as many locations in stock as possible. The system will then project when locations go out of stock and the resulting selling losses that result. Those selling losses will be translated into smaller orders as there is not point delivering goods after they are needed and therefore in excess of what is needed. Selling induced stockouts are not the only kind our system will forecast and react to. Presentation quantities in excess of what is needed to support selling can also cause stockouts. Since in many cases an order coverage cycle will embody many distribution cycles and therefore many distributions, if a distribution includes supplying presentation quantities well in excess of the projected selling then that action can lead to stockouts in subsequent distributions that a system that did not model out would not know about. Therefore, we forward forecast time increment by time increment (usually day by day) the inventory situations of all the inventory stocking locations to determine when selling, presentation or other induced stockouts take place.

Therefore, like the distribution *DemandProxy* calculations, the order and post allocation calculations take into account stockouts. The equations are the same except that the *DemandProxies* used in the *OrderPipelineModelStock* and in the *SumOfLowerModelStocks* are all stockout corrected:

$$\begin{aligned} &\mathit{OrderQuantityStockoutCorrected} = \\ &\mathit{OrderPipelineStockoutcorrectedModelStock} + \\ &\mathit{SumOfLowerModelStocksStockoutCorrected} - \mathit{LocationOnHand} - \\ &\mathit{LocationOnOrderInTransit} - \mathit{LowerOnHand} - \mathit{LowerOnOrderInTransit} \end{aligned}$$

The stockout correction of forward forecasting works well in concert with another correction referred to as need adjustment. The need adjustment is factored

into an allocation or an order using the following modification to the calculation equations:

OrderQuantity = *OrderPipelineModelStock* + *SumOfLowerModelStocks* – *LocationOnHand* – *LocationOnOrderInTransit* – *LowerOnHand*- *LowerOnOrderInTransit* + *NeedAdjustment*

or

OrderQuantityStockoutCorrected = *OrderPipelineStockoutcorrectedModelStock* + *SumOfLowerModelStocksStockoutCorrected* – *LocationOnHand* – *LocationOnOrderInTransit* – *LowerOnHand* – *LowerOnOrderInTransit* + *NeedAdjustment*

and

AllocationQuantity = *AllocationPipelineModelStock* + *SumOfLowerModelStocks* – *LocationOnHand* – *LocationOnOrderInTransit* – *LowerOnHand*- *LowerOnOrderInTransit* + *NeedAdjustment*

or

AllocationQuantity = *AllocationPipelineStockoutCorrectedModelStock* + *SumOfLowerModelStocksStockoutCorrected* – *LocationOnHand* – *LocationOnOrderInTransit* – *LowerOnHand* – *LowerOnOrderInTransit* + *NeedAdjustment*

Where the variables are described below.

The *AllocationPipelineModelStock* is calculated for the Allocation Pipeline coverage cycle, for example shown in Figure 3-4, in a manner identical to the *ModelStock* described above in the distribution calculation, except that it is done for the Allocation Pipeline coverage cycle and using the time period *DemandProxies* supplied for the Allocation Pipeline coverage cycle for the specific time period being done and recognizing that frequently it is not done for a coverage cycle that includes presentation quantities and SDMs.

The *AllocationPipelineStockoutCorrectedModelStock* is calculated as is the *AllocationPipelineModelStock* except where except that the *DemandProxies* used in the *AllocationPipelineModelStock* and in the *SumOfLowerModelStocks* are all stockout corrected.

NeedAdjustment is equal to the sum across all stocking locations served by the initial stocking location of the amount that the current onhand and intransit exceeds the expected sales on the last day or other period of a predetermined selling period. The simple example of this is shown in Figure 11 for two stores where both stores in total have 50 units on hand one day zero. However, one had 5 units on hand and the other has 45 and neither have anything intransit. Each store is forecast to sell 25 items over the course of the coverage cycle and therefore if the inventory was in the correct place they would need no further items to support all the selling (this example ignores safety stock). However, because the stock is not in the correct place the 50 units can not support the 50 sales and some of the units in the overstocked store, namely the 20 units left at the end in Store 2 are not needed and the other store, store 1 will sell less than its full potential of 25 because it is understocked. So the Need adjustment recognizes that for stocking purposes for this example coverage cycle the effective on hand was not 50 but 50 – 20 = 30 and therefore there was a need adjustment of 20 needed to accurately represent what was on hand in a mode that many retailers use where inter-store transfers are not allowed. The projected demand requirement for the selling location is increased corresponding to all or part of an excess quantity of the good at at least one selling or stocking location. Totals across selling locations are rolled up, as in other methods described above.

We take this one step farther in that we do not only determine which locations are overstocked now and correct for that, but we forecast forward locations that may become overstocked and those corrections required. This again is probably worth more explanation as there are many factors that could lead to a location that is not overstocked today becoming overstocked during an activity cycle. One common driver is that there is a future event planned that requires a substantial presentation quantity which is in excess of what would be required to simply support the selling. If you just look to the end of the cycle and not at what is occurring during the cycle then you could miss the presentation or other factor induced overstocking. You would also not know which locations are impacted and which may not be. Therefore our system works through all the locations from the start of the cycle to the end of the cycle determining all the overstocks and all the potential understocks and factoring that into what is needed in orders, post allocation or distributions.

Our system can also run other corrections where store transfers are allowed and therefore overstocks can be moved from the overstocked location to another location that needs it. In that case the system factors in the transfer time and will move stock as required by user selections of first moving overstock inventory or moving overstock inventory only as normal shipment inventory is not available. These differences will then alter or eliminate the Need Adjustment as well as potentially impact the stockout calculations.

An additional real world consideration is discontinuation of a good from one or more selling locations. When items are discontinued in locations, they may be taken off of the active SKU list or they can have an out date of some form set. Out dates come in different modes like an out date that is when you stop fully supporting and achieving the desired *DemandProxy*, such as an inventory level, whether based on economics or a desired service level or some other criteria. There is a more extreme out date often called "last sale out date" beyond which the item will be removed from display and moved to an outlet location or sold off to a clearance retailer. There are also out dates that are distribution center driven where a "last purchase order receive date" is set after which no more shipments will be received in the distribution center. After that point in time then locations will fall below their model stocks and be allowed to go out of stock. The same set of goals can be achieved using deauthorization dates after which an item is no longer optimally stocked in a location or ordered into a distribution center. Or you can have the item move to a non active SKU list (which could vary by location).

Out dates work in somewhat the reverse manner as in dates, once an order cycle crosses the out date boundary for a part of the cycle that part of the cycle is eliminated from the analysis for the particular good (e.g., the *DemandProxy* can be zeroed for dates after the out date.) Out dates can be set as a single date for all stores or set differently for each store. Frequently these would be set regionally with products being discontinued at different times in different parts of a country. So in the example in Figure 13 Store 1 and Store 800 of Regional DC 1 and Store 801 and Store 1400 of Regional DC 2 have crossed the out date line and therefore their future requirements will be excluded from an ordering activity and all other coverage cycles (e.g., Order pipeline, post allocation, National Distribution Cycle, and DC to Location Cycle determination in Figure 13). Now given that each location could have a

different end point for the total order cycle and/or a different out date it means that some locations could be included and others excluded.

Last purchase order receive dates work somewhat like out dates but usually are set at the DC not individual location level (unless the locations receive orders directly from suppliers) and therefore are the same date for all the stores served by a DC. Once the coverage cycle feeding goods to the DC crosses the Last purchase order receive date then all the store selling locations are removed from generating needs for ordering, allocation or distribution activities supplying the DC. There are other dates which may get used by different clients and are incorporated into our system that function in similar manners like last sale out date which shares characteristics with out dates and commitment dates which share characteristics with in dates.

Last sale out dates trigger like out dates but instead of just turning off orders, allocations or distributions actually signal the stop of selling with the remaining inventory sold off by other means such as outlet stores or goods liquidators. Commitment dates which can be the equivalent to an in date used to generate commitments that precede firm purchase orders. They trigger in the same way as an in date with the part of the total coverage cycle being utilized in the calculation.

The impact of a multi-layer distribution network with examples of multiple paths to selling locations is illustrated in figure 11. As the various coverage cycles move beyond the respective selling out dates, whatever projected demand requirements have been forecast can be zeroed for all dates after the selling out dates that have passed. Similarly, as the distribution time moves beyond the last PO receipt date, the respective good-selling location pairs supplied from the stocking location with that last PO receipt date can be zeroed for all dates after the last PO receipt date has passed.

Thus, the aspects of the present invention include a number of corrections to a projected demand requirement or forecast, to take into account practical realities of selling goods.

While the present invention is disclosed by reference to the preferred embodiments and examples detailed above, it is understood that these examples are intended in an illustrative rather than in a limiting sense. It is contemplated that modifications and combinations will readily occur to those skilled in the art, which

modifications and combinations will be within the spirit of the invention and the scope of the following claims.

We claim as follows: